Frog Fungus

High School, Life Science

Task Overview

In this task, students will evaluate a series of models to determine how a mysterious fungus is impacting populations in a pond ecosystem. First, students will look at the impact of the fungus on populations of frogs and crayfish. Students then use their understanding about cause-and-effect relationships to make predictions about how changes in the frog population will affect other populations in the ecosystem. Students will develop their own mathematical model to demonstrate their understanding of these relationships and make predictions about how these relationships would vary in a different environment.

Background Information[1]

As early as the late 1970s, frog species around the world began to disappear due to chytridiomycosis, a fungal disease that infects amphibians, including frogs, toads, and salamanders. Over 500 species of amphibians have seen drastic population decline and at least 90 species are believed extinct as a direct result of the fungus. Scientists have determined that when amphibians are reintroduced to ecosystems where there are no longer any frogs infected by the fungus, they are still unable to survive. This is because the fungus can live in hosts such as crayfish, which although affected by the fungus, do not see the same sharp declines as amphibians in the same habitat. The introduction of this limiting factor of disease can affect predator-prey relationships in various ecosystems in different ways. This task uses mathematical modeling to evaluate how the decline of the frog population due to the introduction of the fungus negatively impacts predators (herons) and positively impacts their direct competitors (turtles). They then predict how the same populations in larger aquatic ecosystems can be affected by the same fungus in similar or different ways.

[1] https://theconversation.com/deadly-frog-fungus-has-wiped-out-90-species-and-threatens-hundreds-more-113846

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Next Generation Science Standards

Three-Dimensional Claim

Use and develop models to predict how the effects of a limiting factor on the carrying capacity of one species can affect the carrying capacity of other organisms in the ecosystem and the health of the entire ecosystem, and these smaller scale mechanisms can be used to predict the effects of the same limiting factor on populations in a larger ecosystem.

This task is intended to elicit student learning of the following **NGSS elements** for each of the three dimensions:

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems (HS)

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. ~~Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.~~

LS2.C: Ecosystem Dynamics, Functioning, and Resilience (HS)

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources ~~and habitat availability.~~

Science and Engineering Practices

Developing and Using Models (HS)

- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

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Crosscutting Concepts

Cause and Effect (HS)

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Suggestions for Use

This task is intended to be used for formative assessment purposes - to identify students' strengths and needs with the above dimensions in order to provide feedback to students and guide shifts in instruction.

Assumptions

Students should have engaged with instructional experiences that ask them to develop and use mathematical models to describe cause and effect relationships. Students should also have a systems understanding and how populations impact one another in an ecosystem, specifically feeding relationships, carrying capacity, and the factors that can limit population size, such as disease, competition, and availability of food resources.

Materials Needed

- Frog Fungus Student Task
- Colored pencils (optional)

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Assessment Guidance

Prompt 1

Look at Model 1 and Model 2 below, which show two key organisms in a pond ecosystem:

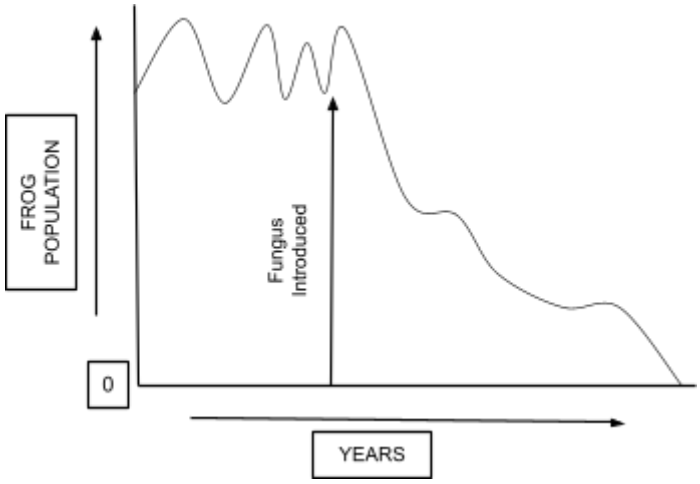
Frogs



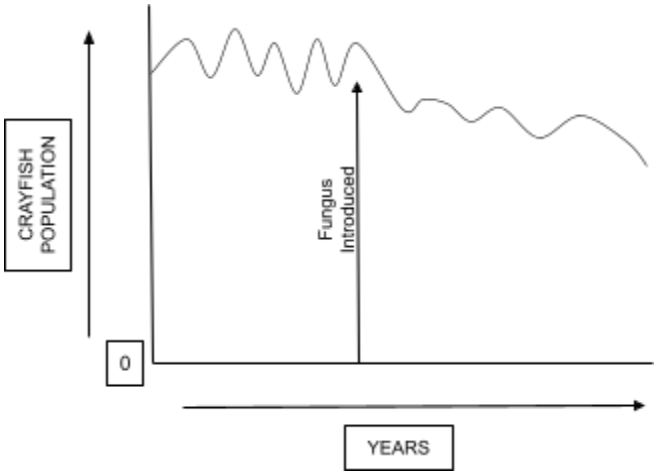
Crayfish



Model 1. Frog Population Over Time



Model 2. Crayfish Population Over Time



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a. Use Models 1 and 2 above to describe the changes in the frog and crayfish populations:		
	The population BEFORE the introduction of the fungus…	The population AFTER the introduction of the fungus…
Frog Population		
Crayfish Population		

b. How are the carrying capacities of the frog and crayfish populations changing in different ways? Use evidence from Model 1 and Model 2 to support your answer.

c. What might be a limiting factor in the pond ecosystem that is causing the carrying capacities of the frog and crayfish populations to change? Use evidence from Model 1 and Model 2 to support your answer.

Prompt 1 Performance Outcome:
Use models to explain how populations of organisms in an ecosystem change due to the introduction of a limiting factor into the environment.

SEP	Use a model based on evidence to illustrate components of a system.
DCI	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as disease.
CCC	Cause and effect relationships can be suggested for complex natural systems by examining what is known about smaller scale mechanisms within the system.

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Prompt 1 Rubric *Part A is not assessed			
	Emerging	Developing	Proficient
Sample Student Response *	*1B. the population went up a few times then eventually just went down.* *1C. frogs are limiting factors and crayfish carry* (irrelevant) ***OR*** *1B. The fungus makes the frogs die and the crayfish less.* *1C. fungus* (relevant) **OR** *1B. frogs and crayfish populations go down.* *1C. fungus* (relevant)	*1B. Assuming that the declines on the graphs represent when the fungus was introduced to the pond the time before it, the frog and crayfish populations were relatively stable until frogs decreased drastically to zero and crayfish went down slightly. Of course there are minor ups and downs with populations, but that is to be expected.* *1C. The fungus was introduced. You can see it as a line on the model.*	*1B. The graph shows the frog population going up and down and then drastically decreasing which shows me that the carrying capacity is drastically lowered. The crayfish population looks similar before the fungus is introduced but only lowers slightly which tells me that the carrying capacity for crayfish is only slightly lower.* *1C. The limiting factor is the introduction of the fungus. The graph shows that with the introduction of the fungus both populations decrease.*
Look-Fors	• Uses a model to describe relevant changes in populations that are **not** specific to how the populations change in different ways change in both populations **and does not connect**	• Uses model to describe relevant changes in populations that **are** specific to how the populations change in different ways **but does not connect** changes in populations to carrying capacity (1b)	• Uses model to describe relevant changes in populations that **are** specific to how the populations change in different ways **and explicitly connects** changes in

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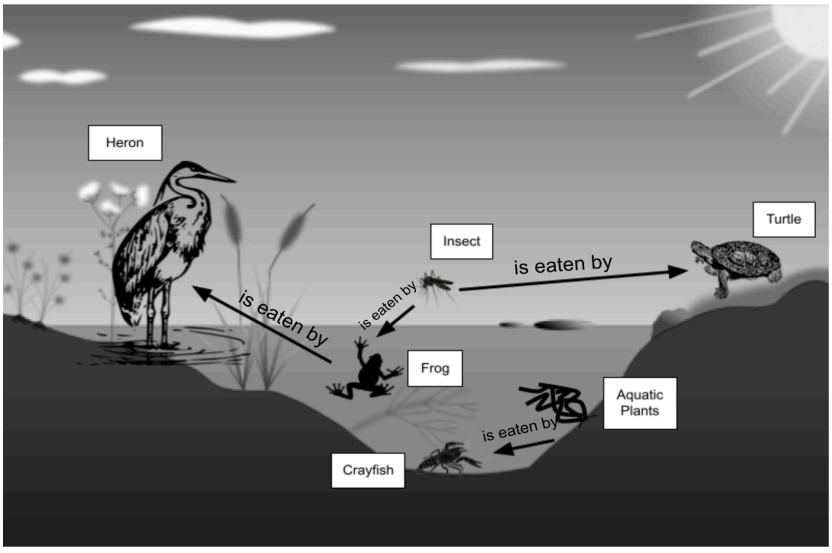
	changes in populations to carrying capacity (1b) **AND/OR** • Suggests an **irrelevant** limiting factor in the environment (1c)	**AND** • Suggests a **relevant** limiting factor in the environment and **implicitly** connects to a change in population (1c)	populations to carrying capacity (1b) **AND** • Suggests a **relevant** limiting factor in the environment and **explicitly** connects to a change in population (1c)

Prompt 2

No other organisms in the pond ecosystem appear to be affected by the fungus, but scientists are worried about the overall health of the pond ecosystem.

Model 3 below shows the relationships between frogs, crayfish, aquatic plants, turtles, and herons in the pond ecosystem. The arrows show feeding relationships in the ecosystems. For example, frogs are eaten by herons, so the arrow goes from the frog towards the heron.

Model 3. Pond Ecosystem



Predict how the introduction of the fungus to the pond ecosystem changes the carrying capacity for turtles and herons. Use evidence from Models 1 and 3 to support your answer.

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After the introduction of the fungus, I predict that the **turtle** population will _____ and the **heron** population will _____.

The models support this because…

Prompt 2 Performance Outcome: Use a model to predict how the effects of a limiting factor on one species in an ecosystem can affect other populations of organisms in the ecosystem and the health of the entire ecosystem.	
SEP	Use a model to predict relationships between components of a system.
DCIs	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living resources. A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. Extreme fluctuations in the size of any population, however, can challenge the functioning of ecosystems in terms of resources.
CCC	Cause and effect relationships can be predicted for complex natural systems by examining what is known about smaller scale mechanisms within the system.

Prompt 2 Rubric			
	Emerging	Developing	Proficient
Sample Student Response	After the introduction of the fungus, I predict that the turtle population will *be negatively affected* and the heron population *will die off*. The models support this	After the introduction of the fungus, I predict that the turtle population will *increase* and the heron population will *slowly decrease*. The models support this	After the introduction of the fungus, I predict that the turtle population will *increase* and the heron population will *decrease*. The models support this because *the food turtles eat*

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	because *the food web will be messed up, as well as the energy pyramid.*	because *it seems as though the herons and turtles rely on the animals that have been negatively affected so they will also be negatively affected.*	*(insects) is no longer being eaten by frogs, meaning an abundance of food for turtles and growth. The heron would decrease due to lack of food (frogs).*
Look-Fors	• Uses the model to make **at least one** accurate prediction about indirect effects on turtle **OR** heron population **AND/OR** • Provides **limited to no** evidence from the model **and/or irrelevant** reasoning.	• Uses the model to make **at least one** accurate prediction about indirect effects on turtle **OR** heron population **AND** • Provides **partial** evidence from the model and reasoning about interactions between living resources that is **too general** to **fully** explain the numbers and types of organisms in an ecosystem.	• Uses the model to make accurate **predictions** about indirect effects on **both** turtle **and** heron populations **AND** • Provides **sufficient** evidence from the model and **cause and effect reasoning** about interactions between living resources to **fully** explain the numbers and types of organisms in an ecosystem.

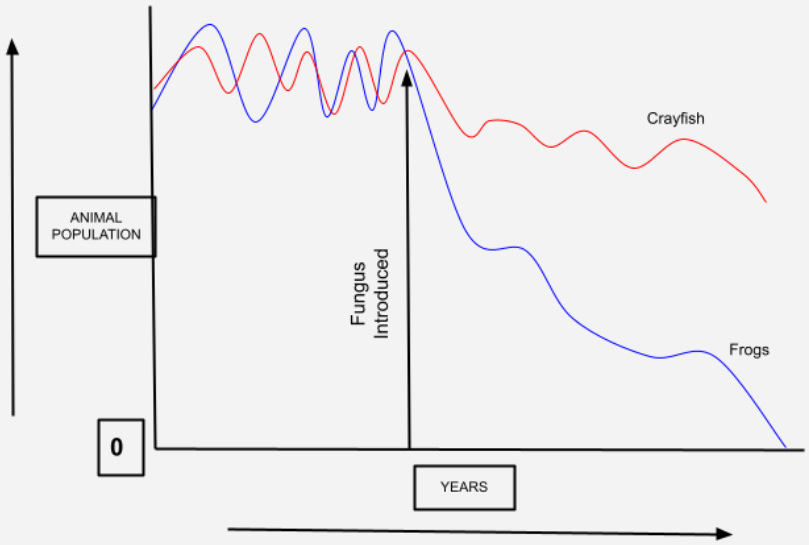
Prompt 3

a. On the model below, draw and label:
- The changes/fluctuations in the turtle population size
- The changes/fluctuations in heron population size

Model 4. Animal Populations in Pond Ecosystem Over Time

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b. How will the introduction of the fungus to the pond ecosystem change the carrying capacity for turtles and herons? Use evidence from the model you created above to support your answer.

Based on my model, I predict that the introduction of the fungus will change the carrying capacity for **turtles** by…

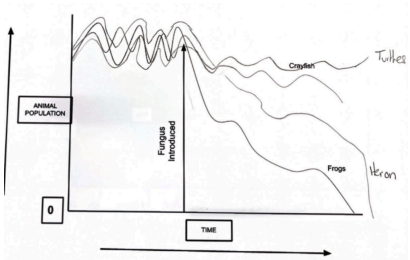
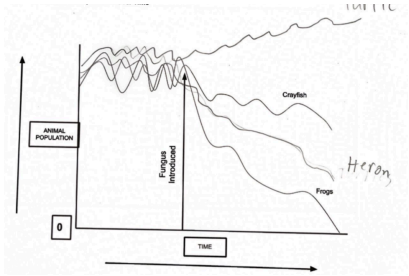
Based on my model, I predict that the introduction of the fungus will change the carrying capacity for **herons** by…

Prompt 3 Performance Outcome:
Develop a model to explain how changing the size of one organism's population affects the size of another organism's population.

SEP	Revise a model to illustrate and predict relationships between components of a system.

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Prompt 3 Rubric			
	Emerging	Developing	Proficient
Sample Student Response	A. blank - no lines or irrelevant markings  B. Based on my model, I predict that the introduction of the fungus will change the carrying capacity for turtles by *making it less.* Based on my model, I predict that the introduction of the fungus will change the carrying capacity for herons by *making it change.*	A.  *(the model should show the turtle population increasing, but this student's model shows it staying relatively stable)* B. Based on my model, I predict that the introduction of the fungus will change the carrying capacity for turtles by *increasing* Based on my model, I predict that the introduction of the fungus will change the carrying capacity for herons by *decreasing a lot.*	A.  *(the model shows heron population decreasing and turtle population increasing)* B. Based on my model, I predict that the introduction of the fungus will change the carrying capacity for turtles by *increasing.* Based on my model, I predict that the introduction of the fungus will change the carrying capacity for herons by *decreasing.*
Look-Fors	• Revisions to the model are **missing, inaccurate, or irrelevant** **AND/OR**	• Revises the model to illustrate the carrying capacity of all organisms in the	• Revises the model to **accurately** illustrate the carrying capacity of **all** organisms in the ecosystems

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	• Uses the model to make **general or irrelevant** predictions about the carrying capacities of turtle **and/or** heron populations	ecosystems **with minor inaccuracies** **AND/OR** • Uses the model to make **accurate** predictions about the carrying capacities of turtle **and** heron populations	**AND** • Uses the model to make accurate predictions about the carrying capacities of turtle **and** heron populations

Prompt 4

The pond ecosystem you have explored is an example of a smaller scale aquatic ecosystem. Lakes, swamps, and large wetland complexes are examples of larger aquatic ecosystems. There is a lake that has the same organisms as the pond, but also has ducks and fish.

a. In the table below, use previous models to describe what each organism eats. Information related to ducks and fish has been added for you.

Population	Food Source(s)
Frogs	
Crayfish	
Turtles	
Herons	**_____, fish**
Ducks	**Insects, aquatic plants**
Fish	**Worms**

b. If a larger aquatic ecosystem, like the lake in Model 5, is infected with the mysterious fungus, predict what will happen to the health of the entire ecosystem?

PREDICTION:

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To support your prediction, use <u>all</u> the evidence you gathered throughout this task and reasoning to explain how all of the populations from the table above will be affected in the larger ecosystem.

EVIDENCE with REASONING:

Prompt 4 Performance Outcome:
Use models of mechanisms within a smaller scale ecosystem to make predictions about the effects of the same limiting factor on populations in a larger ecosystem.

SEP	Use models to predict relationships between components of a system.
DCI	A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. Extreme fluctuations in the size of any population, however, can challenge the functioning of ecosystems in terms of resources.
CCC	Cause and effect relationships can be predicted for complex natural systems by examining what is known about smaller scale mechanisms within the system.

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Prompt 4 Rubric *Part A is not assessed			
	Emerging	**Developing**	**Proficient**
Sample Student Response *	**Prediction:** *the populations will change over time.* **Evidence with Reasoning:** *some decreases and some increases.* *because of the models.*	**Prediction:** *I believe that the lake will be negatively affected but not as much because they have more resources.* **Evidence with Reasoning:** *The frog and crayfish decrease because of the fungus. The other model has the herons decreasing because of frogs but maybe not as much because they now have fish. The turtles won't explode as much.*	**Prediction:** *If we use the previous pond models to predict the outcome of introducing the fungus to the lake, a larger scale aquatic ecosystem, I don't think the effects would be as negative.* **Evidence with Reasoning:** *The first graphs show the frog and crayfish decreasing with the introduction of the fungus. The food web explains what organisms eat what in a smaller aquatic ecosystem. My model showed the turtle increasing because of more insects, due to frogs dying but in the lake, the duck also eats insects, so the turtle population might not increase as much. I had also said the herons are potentially decreasing because of lack of frogs but they also have fish in the lake ecosystem and can still have crayfish so they might not decrease in the lake.* The impact of the fungus on the populations in the

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			lake ecosystem will be much less because there are more food sources for each of the organisms.
Look-Fors*	• Makes **an irrelevant** prediction about the impact of the fungus on a larger scale aquatic ecosystem **AND/OR** • Provides **limited to no** evidence from the models and/or **irrelevant** reasoning.	• Makes a **relevant** prediction about the impact of the fungus on a larger scale aquatic ecosystem **AND** • Provides **partial** evidence from models of smaller-scale mechanisms and **reasoning** about interactions between living resources that is **too general to fully** explain how the fungus could impact a larger ecosystem (lake) differently than a smaller ecosystem (pond).	• Makes a **relevant** prediction about the impact of the fungus on a larger scale aquatic ecosystem **AND** • Provides **sufficient** evidence from models of smaller-scale mechanisms and **cause and effect reasoning** about interactions between living resources to **fully** explain how the fungus could impact a larger ecosystem (lake) differently than a smaller ecosystem (pond).

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